GEOTECHNICAL INVESTIGATION
LIGHT POLE FOUNDATION AND PAVEMENT DESIGN
SOLID WASTE FACILITY, CITY OF HOUSTON
5614 NECHES
HOUSTON, TEXAS

REPORT TO:

REKHA ENGINEERING, INC.
HOUSTON, TEXAS

BY

BANDY & ASSOCIATES, INC.
HOUSTON, TEXAS

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Rekha Engineering, Inc.
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Houston, Texas 77040

Attention: Mr. John English

GEOTECHNICAL INVESTIGATION
LIGHT POLE FOUNDATION AND PAVEMENT DESIGN
SOLID WASTE FACILITY, CITY OF HOUSTON
5614 NECHES
HOUSTON, TEXAS

Gentlemen:

We are pleased to submit our report on the geotechnical investigation for the referenced project. This study was authorized by Mr. John English.

INTRODUCTION

This report presents field and laboratory data and recommendations for the light pole foundation and design and construction of pavement. Two (2) copies of the report are being transmitted herewith.

The purpose of this investigation was to determine the various soil profile components, the engineering characteristics of the sub soils at the site and to develop recommendations for light pole foundation and designs of pavement.

The scope of the exploration and analysis included the subsurface exploration field and laboratory testing and engineering analysis and evaluation of the subsurface materials.

The soils engineer warrants that the findings, recommendations, specifications, or professional advice contained herein, have been promulgated after being prepared in accordance with generally accepted professional engineering practice in the field of foundation engineering, soil mechanics and engineering geology. No other warranties are implied or expressed.

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FIELD EXPLORATION

Subsurface conditions at the site were defined by two (2) undisturbed sample borings, B-1 and B-2, located in plan as shown on Plate 1.

The borings were drilled to depths of ten (10) feet below the existing ground surface. The soils encountered are shown on the log of borings, Plates 2 and 3. Where possible, undisturbed samples were obtained using thin-walled Shelby tube samplers in general accordance with the procedure outlined in ASTM D-1587. In cohensionless soils, the standard penetration test and split-barrel sampling were conducted simultaneously using ASTM Specification D-1586 as a guide. Depth to water was measured in open boreholes after completion of drilling and when possible at different intervals during the course of the field operation. Unless notified to the contrary, all samples will be disposed of after sixty (60) days subsequent to submittal of this report.

LABORATORY TESTING PROGRAM

Classification tests consisting of liquid and plastic limits, percent fines and moisture content determinations were performed to evaluate general uniformity of the soil conditions and shrink-swell potential of these soils. Results of these tests are tabulated on the boring logs at respective sample depth.

Undrained shear strength properties of cohesive soils were defined by unconfined compression tests on undisturbed samples. Results of these tests are tabulated on the boring logs.

All phases of the laboratory-testing program were conducted in general accordance with applicable ASTM Specifications.

SITE AND SUBSURFACE CONDITIONS

General

The stratification of the soils, as shown on the boring logs, represents the soil conditions in the actual boring locations, and other variations may occur between the borings. Lines of demarcation represent the approximate boundary between the soil types, but the transition may be gradual. Should conditions be found to vary between boring locations during construction, Bandy & Associates, Inc. should be contacted to review recommendations and revise them, if necessary.

Description of Foundation Materials

The surface of the proposed construction site is presently covered with very stiff to stiff dark gray and brown to light gray and yellow clay, continuing to completion depth of the borings. The clay stratum is medium in plasticity with Liquid Limits of 23 to 36 and Plasticity Indices of 10 to 21. Moisture content ranges from 14 to 21 percent.

Groundwater Observation

No groundwater was encountered in open borehole at the time of drilling.

ANALYSES AND RECOMMENDATIONS

Foundation Type and Depth

Various foundation types have been considered for the support of the light poles. The foundation types considered included underream footings.

Underream footings are used most advantageously when relatively soft or expansive strata overlie a firm to stiff foundation material. Soil conditions at the boring locations and the magnitude of the proposed loads indicate that underream footings may be used. It is recommended that **underream footings be founded at depths of seven feet (7') below the existing grade**. A representative of soils engineers should be present during drilling of underream footing so that depth of footings be adjusted, if needed, depending on soil conditions at each footing location. Concrete should be placed in the drilled piers immediately after excavation to reduce the risk of groundwater seepage, deterioration of the foundation bearing surface and underream collapse.

Allowable Bearing Values

The field and laboratory strength data were utilized to determine allowable soil loading as a function of foundation shape and depth. Analyses indicate that underream footings can be dimensioned for net allowable bearing capacity of 2600 psf. This bearing capacity can be increased by 25 percent for transient loads. A shaft to bell ratio of 1:2 to 1:3 is recommended. Underream footings should not be spaced closer than two (2) underream diameters (edge to edge) based on the diameter of the larger underream. If a clearance of two bell diameter cannot be maintained in every case, the above bearing capacities should be reduced by 25 percent for a clearance between one and two bell diameters. Drilled footings closer than a clearance of one bell diameter are not recommended. The uplift force on the piers, due to swelling of the expansive clays, can be approximated by assuming a uniform uplift pressure of 1000 psf acting over the perimeter of the shaft. The shafts should contain sufficient full length reinforcing steel to resist uplift forces.

Foundations proportioned in accordance with the above value will have a factor of safety greater than two with respect to shear failure. Footing weight below final grade can be neglected in the determination of design loading. It is estimated that underream footings will experience total settlements of less than one-inch after construction.

For underream footings, **ultimate** uplift capacity can be computed from the following equation provided that ratio of pier depth to bell diameter is equal or greater than 1.5.

$$Q_u = 5.2C\ (D^2 - d^2)$$

Where:

Q_u = **Ultimate** uplift capacity, psf

C = Shear strength of soil = 800 psf

D = Diameter of bell in feet

d = Diameter of shaft in feet

A factor of safety of at least two (2.0) is recommended.

Because of the potential for the upper two feet of the soil to shrink and pull away from drilled piers during dry periods, we recommend soil resistance to lateral loads on drilled piers be ignored in the upper 2-feet of the soil profile. For resistance of lateral loads on drilled piers, we recommend the following parameters that include a factor of safety of 3.

Depth (ft)	Soil Type	Effective Soil Unit Weight (pcf)	Allowable Cohesion (psf)	Angle of Internal Friction,Φ (degrees)	Strain at ½ Peak Strength, ε_{50}	Horizontal Modulus of Subgrade Reaction (tons per cubic foot)
0 - 2	Clay	120	0	0	NA	NA
2 - 10	Clay	120	700	0	0.007	110

PAVEMENT DESIGN

Traffic

The traffic mainly will consist of heavy trucks. Concrete pavement structure is recommended.

Subgrade

The existing subgrade consists of low to medium plasticity clay with low swell potential over time. For low to medium plasticity subgrade, it is recommended that upper six (6) inches of the subgrade be stabilized with six percent (6%) lime (28 lb per sq. yd.) or four percent (4%) Portland cement (20 lb per sq. yd.) by dry weight. The stabilization may be performed in accordance with Item 260 and 275 of TxDOT Specifications.

Base

A base course should always be used under concrete pavements. The choice of type of base course depends essentially upon the economics of the area. The primary function of the base is to prevent pumping and, hence, it must be either free-draining or highly resistant to the erosive action of water. To provide drainage, the base must contain little or no fines.

A nontreated granular base course placed under a concrete pavement to control pumping must fulfill two requirements. They are: (1) it must prevent the subgrade soil from pumping through the base, and (2) it must not pump itself. To be a nonpumping material, a nontreated base course must contain little or no fines and experience has shown that they should be open textured.

If the open-graded and drained concept is to be used under concrete pavements, it is necessary to provide adequate drainage facilities so that water can escape from under the pavement. This can be accomplished by extending the base course through the shoulder or providing edge drains depending on the economics of the situation.

Crushed limestone base is recommended for the base course. Bases that are used under concrete pavements should be at least six (6) inches in thickness. The base material should be compacted to at least 95-percent of its Standard Proctor Density

(ASTM D-698). A void ratio of 0.43 may be used for the base course.

Jointed Reinforced Concrete Pavement

Concrete pavement thickness has been determined based on AASHTO design method (AASHTO Guide for Design of Pavement Structures). The following parameters are used for the design:

K = Effective Modulus of subgrade reaction for base
= 600 pci

E_c = Concrete Elastic Modulus = 5 $x10^6$ psi

S_c = Mean Concrete Modulus of Rupture = 650 psi

J = Load transfer Coefficient = 3.2

C_d = Drainage Coefficient = 1.0

S_o = Overall Standard Deviation = 0.25

R = Reliability = 95%

PSIΔ= Design Serviceability Loss = 2.0

W_{18} = Design 18-Kip Equivalent Single Axle Load
= 5 x 10^6 ESAL

Using Figure 3.7, Part II, Design Chart for Rigid Pavement, design thickness of concrete pavement is 8.5 in. for $5X10^6$ ESAL.

Recommended Design Section:

a. Design Traffic = $5X10^6$ ESAL

Concrete thickness = 8.5 in.

Crushed Limestone Base Thickness = 6.0 in.

Lime or Cement Stabilized Subgrade = 6.0 in.

(6% lime or 4% cement by dry weight)

Estimated void ratio: 0.43

PAVEMENT REINFORCEMENT DESIGN

The purpose of distributed steel reinforcement in reinforced concrete pavement is not to prevent cracking, but to hold tightly closed any cracks that may form, thus maintaining the pavement as an integral structural unit. The physical mechanism through which cracks develop is affected by (1) moisture-related slab contractions, and (2) frictional resistance from the underlying material. As temperature drops or moisture content decreases, the slab tends to contract. This contraction is resisted by the underlying material through friction and shear between it and the slab. The restraint of slab contraction results in tensile stresses which reach a maximum at midslab. If these tensile stresses exceed the tensile strength of the concrete, a crack will develop and all the stresses are transferred to the steel reinforcement. Thus, the reinforcement must be designed to carry these stresses without any appreciable elongation that would result in excessive crack width.

Using Figure 3.8, the steel reinforcement required is 0.08% for slab length of 30 feet, Friction factor of 1.5 and steel working stress of 30,000 psi.

Proper finishing of concrete pavements requires the use of sawed and sealed joints, which should be designed in accordance with current Portland Cement Association guidelines. Joint spacing is recommended at 30 feet intervals for jointed reinforced concrete pavement. Dowel bars should be used to transfer loads at the joints.

Related civil design factors such as drainage, cross-sectional configurations, surface elevations and environmental factors, which will significantly affect the service life, must be included in the preparation of the construction drawing and specifications. Normal periodic maintenance will be required.

SLOPE STABILITY ANALYSES FOR DETENTION POND

Slope stability analyses of the proposed detention pond were performed in accordance with procedures enumerated in Design Manual NAVFAC DM-7, Department of the Navy, Alexandria, Virginia, as shown below. The soil is uniform in stratigraphy and can be termed as low to medium plasticity clay with moderate shear strength.

Rotational Failure in Cohesive Soil

Refer to Figure 7-1 of the manual (Attached). Use lowest undrained shear strength value of the soil from the borings obtained from unconfined compression tests and reduce the shear strength by 50 percent to account for strength loss due to weathering of the exposed soil.

$H = 4$ ft

Assume $D = 0$

$d = D/H = 0$

Lowest Laboratory Shear Strength: 800 psf

Reduce Shear Strength by 50% to account for weathering and other causes

Design $C = 0.50 \times 800 \approx 400$ psf

$\gamma_T = 115$ pcf

Slope $b = 3$

For Toe Circle failure, $d = 0$

From Chart, Stability Number N_o=11

$$\text{Factor of Safety } F_S = \frac{N_O\ C}{\gamma_T H} = \frac{(11)400}{(115)(4)}$$

$$= 9.6$$

O.K

We appreciate the opportunity to perform this study. Please call upon us if you have any questions.

Very truly yours,

BANDY & ASSOCIATES, INC.

S. S. Bandy, Ph.D., P.E.
President

SSB/mh
Copies Submitted: 2

STANDARD NOTES

1. Geotechnical Engineering and Quality Control Testing services by this firm are recommended during construction.

2. We have endeavored to analyze the site foundation conditions in accordance with basic geotechnical engineering principles; however, we are not aware of all the loading or structural conditions; therefore, we suggest that your professional staff carefully review our report for any design criteria for which we may not be familiar, or for which we may have inadvertently omitted. Accordingly, the contractual documents should advise that no claims will be allowed as a result of our geotechnical investigation and recommendations.

3. If any conditions are encountered during final design and/or during construction which are materially different that those presented in this report or assumed to exist at the site, this firm should be notified at once so that we may have an opportunity to make further studies and recommendations.

4. This publication is intended for the use of professional personnel competent to evaluate the significance and limitations for its contents and who will accept responsibility for the applications of the material it contains.

5. It is considered prudent and recommended that the soils engineer be consulted further during the final stages of design, and the preparation of plans and specifications, to ascertain that the earthwork and foundation recommendations have been interpreted and implemented basically in accordance with our intent. It thus may be necessary to submit supplementary recommendations to these items. All communications concerning this report must be made in writing.

6. This geotechnical engineering investigation report is not intended to be utilized as an earthwork specification for construction.

ILLUSTRATIONS